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ABSTRACT

Research on teacher education has been shifting from the emphasis on changing teachers' behaviors to investigating how teachers' mental thinking influences their teaching behaviors. Teachers' beliefs and planning are two important components among teacher thinking research. The purposes of this study are to uncover preservice secondary science teachers' beliefs about science and pedagogy and to investigate how preservice science teachers' beliefs about science and pedagogy influence their planning and teaching. This study used qualitative methods such as participation observation, field notes and in-depth interviews. Topics discussed in the interviews included the ways informants planned their lessons, the considerations during their planning, the resources they used in planning, and the reflection on their teaching performance. An open-coding system was generated to analyze data and the data were categorized. The study suggests that although so many preservice teachers articulate similar bliefs, their underlying context may be quite different. Therefore, the best way for science educators to introduce learning theories to their students is for them to explain what they mean by providing substantial reasoning for their responses. Self-reflection on one's action could help these preservice teachers to be aware of their own thinking and performance. (KR)

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The Influence of Preservice Secondary Science Teachers' Beliefs about Science and Pedagogy on their Planning and Teaching

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The Influence of Preservice Secondary Science Teachers' Beliefs about Science and Pedagogy on their Planning and Teaching

Introduction

In the past decade, research on teacher education have been shifted the emphases on changing teachers' behaviors to the investigating on teachers' mental thinking which influence their teaching behaviors. Among teacher thinking research, studies showed that teachers' beliefs, values and personal philosophies influence their learning, instruction and curriculum reforming (Oslon, 1980, 1981; Duff, 1977; Elbaz, 1981; Thompson, 1982; Tabachnick & Zeisner, 1985; Hollon & Anderson, 1987). However, these research focused on different strands of teachers' beliefs, such as describe the features of teachers' beliefs (Elbaz, 1981; Nespor, 1986), or portray how middle or elementary school teachers' beliefs influence their instructions (Tabachnick & Zeisner, 1985; Thompson, 1982), seldom research have done on preservice secondary science teachers. As research (Clark & Peterson, 1986) suggest that teachers' beliefs influence their thinking which consequently influence their teaching performance and their learning. Hence, understanding preservice secondary science teachers' beliefs is quiet important. On the other hand, presumably preservice secondary science teachers have stronger science content knowledge and more maturation in thinking of pedagogy in general and in science area than preservice elementary school teachers, thus, their beliefs about science and

pedagogy would be differ from either preservice elementary school teachers' or teachers in other discipline areas. Better understanding of preservice secondary science teachers' beliefs about science and pedagogy and how their beliefs influence planning and teaching from holistic perspective will help science educators to appreciate their students' mental thinking and to improve their science teacher education program.

Literature Review

Thompson(1982) has studied three junior high school teachers' conceptions of mathematics and mathematics teaching, and has investigated how these conceptions relate to teaching practice. Three case studies of junior high school mathematics teachers were generated by four weeks of observation, interviews and questionnaire which designed to collect data on teachers' views about various aspects of mathematics teaching.

In the end, Thompson's findings support her previous assumption that teachers' conceptions play a significant role in shaping their teaching behaviors. Each teacher has a different conception of mathematics, which makes a difference in their characteristic instructional mode. However, there remains some incongruence between teachers' conceptions and their classroom behaviors.

Thompson has also found complexity in the relationship between teachers' instructional behavior and their conceptions of mathematics and mathematics teaching. Many other factors, such

as general beliefs about teaching, appear to interact with the teachers' conceptions of mathematics and mathematics teaching, affecting their decisions and behaviors. Tabachnick and Zeichner (1985) indicated that although teachers' conceptions influence their classroom behaviors but there exist the incongruence between teachers' conceptions and their classroom behaviors.

Schmidt and Buchmann (1983) have investigated the relationships between teachers' judgments on content emphases, their attitudes toward content areas, their sense of competency in these areas, and the time they allocate to teaching different content areas. Six elementary school teachers are requested to participate in the study. Data consist of logs keeping, questionnaires, field observation. The study finds that both internal and external factors effect teachers' content decisions. The external factors which influence time allocation are determined by policy decisions. The internal factors are determined by the teachers themselves, in line with their attitudes, beliefs, and subject-matter knowledge of the subjects in the curriculum.

Hollon and Anderson (1987) sample middle school science teachers' beliefs about teaching and learning, using conceptual change as an underline framework. Their study addresses how teachers' beliefs about students' learning processes influence their judgments of information importance, their information-gathering strategies, and ultimately, their ability to learn from experience.

Thirteen experienced seventh-grade life science teachers participated in the Middle School Science Project. The teachers were observed as they taught three units in life science. Later, these teachers are labeled as conceptual development, content understanding and fact acquisition orientation.

"Conceptual development" orientated teachers have clearly organized content and instruction, which emphasize students understanding of important concepts. They are not rigidly bound to a particular level of content mastery. Their instruction is flexible, and their instructional goals primarily emphasize students shifting their thinking toward a more scientific understanding of important concepts.

Teachers oriented toward "content understanding" emphasize the introduction of content information. Their classroom teaching is conducted in a very quiet, purposeful atmosphere so they can maximize the passage of information from teacher to student. These teachers always tend to have high expectations for student achievement.

On the other hand, the "fact acquisition" oriented teachers place much emphasis on socialization issues, such as motivation, students' needs, and the limitations on their innate ability. The results of this study support the idea that teachers' orientations toward teaching and learning and their content knowledge influence their curricular goals and teaching strategies, and their ability to learn from experience.

Theoretical Assumptions of this study

Looking back the literature, we can find that the terms used in research on teachers' beliefs vary, such as conceptions, orientation, etc. However, research all address the importance of how beliefs influence on teachers' teaching and learning. The investigation of this study is guided by the assumptions that the individual teachers' provide foundation for teacher thought and actions (Elbaz, 1983; Clark & Peterson, 1986), teachers act as professionals and independent thinkers, who are constantly making decisions in an uncertain and complex environment. Teachers' behavior are directly guided by their thoughts, judgments, and decisions (Shavelson & Stern, 1981).

The term "beliefs" used in this study are integrated by several research such as Scheffler (1965), Abelson (1979), Nespor (1986), and Elbaz (1981). The study defines beliefs as viable truths for an individual whose personal experience must provide evidence in support of particular truths. Beliefs dominate an individual's actions. Belief system consist of various elements (disposition, clusters, constructs) which organize themselves differently depending on the situations or contexts.

Design and Procedures

This study used qualitative method suggested by Bogdan and Biklen (1982). This method is flexible, can be employed to describe the complexity of the social context, and can collect

data on the subjects' own perceptions about the phenomena studied. The reason to choose this method is because research done on teacher thinking (Clark & Peterson, 1986) have tended to focus on narrow or isolated aspects of teacher thought and action in a clinical setting rather than looking at the whole process of teaching in natural setting.

Data collection procedures included the Repertory Grid Technique (Munby, 1982), interviews conducted during methods course, and observations. The primary participants in this study were preservice secondary science teachers, enrolled for the winter and spring quarters of the 1988 academic year in the secondary science methods class and in student teaching assignments at a southeastern university in U.S.

In the first two interviews, the Repertory Grid Technique and interviews were conducted to collect the beliefs about science and pedagogy of these informants. Two more scheduled interviews were conducted followed their two times practicums exercises. Topics touched on in the interviews included the informants' planning, their considerations during planning, the resources used in planning, and the reflection on their teaching performance. I also attended the post conferences these informants had with their college instructors, to discuss their performances in practicums and opportunities for improvement. Three informants selected by their willingness to participate during their student teaching, their classroom teaching was observed by two researchers once a week for eight weeks.

Interview was conducted right after each observation session. Topics focused on the way the informants planned these observed lessons, their consideration during planning, their planning for the following week and following unit, their perceptions about ones' own teaching performance. Data consist of informants' perceptions and two researchers' observations during their field experience. Interviews with the individuals' cooperating teachers served as supplementary data, to provide triangulation on data sources.

All the interviews were audio-taped and then transcribed verbatim. After studying through the transcripts for several times, an open-coding system was generated to analyze all data. At the same time, codes were constantly revised and double checked by other researcher, then classified data into categories. Case studies of each informants were described in Tuan (1990). This paper summarize the findings from three informants' data. A summary of each informant's beliefs, how beliefs influence planning and teaching, and their classroom teaching during student teaching are listed in Appendix I, II and III.

Findings

Background Information

There are three informants participated in this study, they are Tina, Chuck and Sally (all names have been changed to protect their anonymity). This section will brief describe each of them and the context where I get the data from.

Tina is a 23 year-old senior student. She has a very strong chemistry background. She changed several colleges and majors before she attended science education program. She decided to become a secondary science teacher because she wants to help people and she likes to help students succeed in learning. I impression of Tina is that she is a very strong opinionated and ego-centric student. During interviews or informal conversations with her, she constantly expressed her opinions strongly and most of them based on her preferences.

Chuck is a 24 year-old graduate student, married with no children. He has been in Forestry School for five years and obtained a degree in Forest Hydrology. He was working on his certification in geology earth science in the science education program. Chuck did not have previous teaching experience. He was motivated to become a secondary science teachers because he enjoys helping people, and he likes to see students succeed. My experience with Chuck is that he is a very idealistic student teacher. He also has a very creative mind and a willingness to try new things in his classroom teaching.

Sally is a 35 year-old graduate student, married with two children. She obtained her bachelors degree in Zoology eleven years ago. She taught first and second grades in an elementary school before. Her decision to choose teaching as career came from practical concerns about her family. She saw teaching as compatible with her roles as a wife and mother. Sally also enjoyed science, and working with young students. To me, Sally

is a very diligent student teacher, who always studies a lot in preparing her lessons. She has a very good personality and a flexible teaching style to match her students' needs.

Context of teaching

During Tina, Chuck and Sally's practicum, they all taught three-day lesson on junior high school and three-day lesson on senior high school classes. Lessons Tina taught were radio-activity to advanced chemistry students, and earthquake to average middle students, these two public schools are located in university town. Chuck taught lung capacity to seventh graders and human physiology lesson to seniors, these two public schools also allocated in the same college town as Tina. Sally taught physical science and life science at two different urban middle schools.

After practicum experience, these three preservice secondary science teachers were assigned to different public school to have one quarter student teaching experience. Tina taught one 7th grade average mathematics class, one physics class, and two chemistry classes at a rural county high school. Chuck taught eighth graders earth science classes at a rural county middle school. Sally taught several topics, including basic and advanced biology, ecology and earth science, at a rural high school. These three public schools were also allocated in southeastern U.S.

Beliefs

I investigated Tina, Chuck and Sally's beliefs about science and pedagogy using the Repertory Grid Techniques (Munby, 1982), and in interviews in which they discussed classroom events occurring during their practicums and student teaching. Below I describe their beliefs about science and pedagogy.

Beliefs about science

Tina believes that science is constantly changing. It is important to use scientific methods to solve the problems that occur in people's daily lives. She also believes that knowing more science can facilitate people to improve their living environment. It seems like Tina's beliefs about science center around solving environmental problems, which relate to science/technology/society issues.

Chuck expresses the belief that scientific truth is tentative. This belief greatly influences Chuck. He emphasizes the scientific method, constantly checking one's assumptions, and validating and updating them during lab activities. Chuck is primarily interested in using pure scientific method to study nature.

Sally sees science as helping us to understand an unknown, mysterious universe. Science also affects people's daily lives. The more people know about science, the more they know about their environment. Sally's beliefs about science are oriented toward understanding and appreciating natural phenomena in the human environment.

All of the informants believe that science is constantly changing, and, therefore, knowing how to do science is more important than knowing particular scientific facts. They strongly believe that science should be process oriented. Students should study nature and solve problems by constantly hypothesizing, conducting observations, and checking results. I think these student teachers' expressions of their beliefs about science are influenced by their college methods course, which discussed the importance of using science process skills in teaching science.

Beliefs about Pedagogy

Beliefs about Learning

Tina believes that learning should include involvement. For her, this means that students can contribute ideas for managing discipline in their own classrooms. She also believes that learning should be interesting. Students show they are interested in learning by participating in activities which involve discussion or by sharing their experiences in the class. The way to check whether students have learned or not is by students' application of what they have learned in class in their daily lives. Tina believes science learning should consist of concrete, hands-on experiences. Discovery learning experiences are also important for science learning so Tina tries a variety of lab activities. Although Tina was excited in describing her discovery learning, but to me, Tina's idea of discovery learning seems similar to regular college lab activities.

Chuck believes the important components in learning are the individuals' intrinsic motivation, maintaining students' interest, and having students actively participate in learning. Learning should also be enjoyable to students so they feel free to express what they want to learn and talk about in the classroom. For learning science, Chuck believes that understanding science concepts is more important than memorizing terminologies. The best way to learn science concepts is through doing activities. Chuck also places a high value on the experiences students have in performing activities. The quality of the experience is far more important than getting correct results.

Sally believes that learning only comes through the intrinsic motivation of students. Learning does not occur until students become willing to learn something that they see as useful and applicable to them. Students are responsible for their own learning.

They all believe in the importance of using concrete experiences in learning, manipulating objects, actually seeing something, and conducting activities. Students must participate in the learning process and be interested and involved. Many of these informants also think that when students can apply their classroom knowledge in their daily lives, then learning has occurred. These prospective teachers stress the importance of processing and understanding scientific concepts instead of memorizing scientific facts.

There are differences among these student teachers. Tina focuses on students' involvement in learning. In describing learning, she emphasized students' actions instead of students' internal attitudes. In contrast, Chuck and Sally focus on students' internal desire to learn instead of on their learning behaviors. They use a more humanistic approach, providing a pleasant environment to enhance learners' intrinsic motivation to learn.

Beliefs about Teaching

Tina believes that science teachers should provide basic information to students and, then, let students conduct hands-on activities. Tina prefers lectures in her own teaching and uses questions and student interactions. She does not have a strong preference for discussion, unless it is necessary to show the constantly changing nature of science or to discuss lab results. Tina values work-sheets very highly, which she believes enhance student learning.

Tina feels teaching should be interesting, both to students and to herself. The way to maintain student interest is through hands-on activities. To me, Tina's idea of high school science teaching seems similar to the typical college science teaching. Tina also believes that science is too abstract for most students to grasp so teachers should not only water down the scientific language, but should also encourage students to explore different hypotheses during lab activities.

Tina does not have any particular teaching style, actually, she thinks that styles of teaching and the goals of different

lessons should vary, depending on the nature of the lesson. Some lessons should use pure lecture some need to use activities. Some lessons may focus on increasing environmental awareness, while others may focus on familiarizing students with new terminologies. For Tina, teaching involves performance and is fun.

Chuck believes that teaching is a conceptually oriented learning activity, which should involve many group activities and discussions. Ideally, by providing these kinds of learning experiences, students can become independent thinkers and problem solvers. Chuck believes science teaching should not only transfer proper scientific language to the students, but also help students apply what they learn to their daily lives. He hopes, students can then, show a better understanding of their own environment. Finally, teaching should meet students' interests, spark their willingness to learn, and build up their confidence to learn in the future.

Sally believes that the goal of teaching is not only to transfer the fundamental content knowledge to students, but also to help them see the relevance of this knowledge to their daily lives. Teachers should interact a lot with students, matching students' needs and ability levels. Teachers should also maintain a dynamic learning environment by using a variety of teaching methods to maintain students' interest. Finally, teachers should not only encourage a constant curiosity about the world, but should also build up students' confidence to explore the environment.

A synthesis of these findings, regarding teaching, indicates that all of the informants believe that teaching should maintain students' interest in learning and should also help students build their confidence in exploring their environment and in future learning. Most of the teachers value group activities and hands-on activities very highly as ways to maintain students' interest. In addition, transferring content knowledge and introducing basic scientific terminologies is also important goals in their teaching.

Among these student teachers, each seems to have an idiosyncratic teaching style, except Tina who could not conceptualize her beliefs about teaching to me. Tina believes the goal of teaching is flexible and is determined by content and topic. Chuck's teaching is geared more toward providing a pleasant and activity-oriented environment. He also focuses on students' conceptual learning and tries to help students become independent problem solvers. Sally's beliefs about teaching are also focused more toward a traditional teaching pattern based on transferring content knowledge to students. She also emphasizes showing the application of content knowledge to students' daily lives, that is, teaching practical knowledge to students.

Beliefs about the Role of the Teacher

Tina believes that teachers should capture their students' interest by creating an interesting learning environment and stimulating their desire to learn. It is also important for teachers to teach content knowledge to students so teachers

should have strong subject-matter knowledge and organize the information they present to students. Teachers should also be good role models, showing an enthusiastic attitude and good manners.

Chuck believes that teachers should motivate students and provide comfortable, student-centered learning environments. Teachers should also act as role models, showing enthusiasm for learning. They should also help students conceptualize content knowledge.

Sally believes that the teacher should provide a comfortable learning environment for students and should use activities to maintain a dynamic learning atmosphere. The teacher should also be a knowledgeable figure, who knows how to organize content in order to guide students to expand their knowledge. Finally, the teacher should have an enthusiastic attitude toward learning for her students.

A comparison indicates that most of the student teachers have similar perceptions about a teacher's roles They believe teachers should provide a comfortable learning environment, transfer content knowledge to students, and provide good learning models for students. Most of these informants believe an activity-oriented learning environment is best, giving students an opportunity to explore and learn. To facilitate the transfer of content knowledge, most subjects think that teachers should be knowledgeable and know not only the content information from curriculum material, but also how to solve students' learning

problems. As far as modeling learning, these informants believe that teachers' showing enthusiastic attitudes can spark students' interest. Finally, all of the student teachers believe that teachers should share and maintain students' interest in learning and make learning a successful experience for students.

There are some differences among these student teachers. Tina's beliefs focus on teacher competency and strong subject-matter knowledge. She also believes teachers should maintain students' interest in learning. Chuck believes that the teacher should act as a motivator, who constantly sparks student interest by providing an activities-oriented environment. His teaching focuses on conceptual learning. Similarly, Sally believes the teacher should provide an interesting learning environment, but she stresses using activities to maintain a dynamic learning environment where students can learn by themselves.

Beliefs about Students

Tina believes that students will take active roles in the classroom, such as doing lab activities and work-sheets. Participation shows whether students enjoy learning or not. Unfortunately, there was an incongruence between her ideal students and the actual students she taught. Tina realizes that the students in her classroom are very passive in their own learning and depend on the teacher's guidance. They are more concerned about grades than the learning experience. Concerning different level students, Tina thinks that middle school students are not enthusiastic about learning and are not mature enough to

participate in activities. High school students are more mature and more intelligent in learning.

Chuck thinks students should act like adults with intrinsic motivation and responsibility for their own learning. However, his ideas conflicted with the students he taught in his field work. He realizes that students are passive learners, who need to be told to learn, and that they are careless and irresponsible. Chuck believes that because young students lack of basic training and background information, they do not have confidence in learning deep subject-matter knowledge. These students need to use a hands-on approach in learning new content. Chuck thinks eighth graders are a special group. They feel insecure about themselves and lack confidence in trying new activities. On the other hand, seventh graders are more enthusiastic and experimental. Chuck thinks high school students have had enough basic training to give them the confidence to learn deeper subject-matter knowledge.

Sally believes that students should initiate and take responsibility for their own learning. Students should also show an enthusiastic attitude and curiosity about everything around them. Sally thinks that younger students are proactive learners, who cannot sit for long, or conceptualize complicated concepts. However, they are enthusiastic in communicating with the teacher. Older kids are more mature and more independent in learning. They not only know how to control themselves, but can also handle more complicated concepts. During her student teaching, Sally

handled different level students very well, thus she did not mention about conflict views between her ideas with the students she taught in her field work.

These student teachers all refer to themselves as students and think that students should act as adults with a desire to learn and the responsibility for their own learning. Unfortunately, most of their perceptions of students conflict with reality. They realize that students are passive, irresponsible, and depend on teacher guidance to a great extent.

In their perceptions of different level students, most teachers use students' cognitive levels to assess students' learning abilities. They believe that junior high school students are not mature enough to participate in exploratory activities or do individual work. Because their thinking abilities are still concrete, they cannot learn deep, complicated concepts. High school students, the teachers feel, are more autonomous in their learning. They are more capable of conducting activities by themselves, and their thinking levels enable them to grasp complicated concepts.

Chuck and Sally believe that the differences among the different levels of students are based on the students' attitudes toward learning and their physical maturation as it effects their ability to conduct activities. They think young students have a more enthusiastic attitude toward learning than older kids. In contrast, Tina focuses more on students' cognitive abilities than their attitude. They consider the capabilities of older kids to learn more difficult concepts and do more discovery learning.

Relationship between Planning and Beliefs

Tina believes that maintaining student interest in learning is the teacher's responsibility, which causes her to plan a variety of teaching methods. She also strongly believes that work-sheets can enhance student learning. Thus, she spends a lot of time designing work-sheets for her lessons. Her differing perceptions of high school and middle school students cause her to prepare more individual work for high school students and more concrete events for middle school students.

Chuck believes in the importance of maintaining student interest, letting students learn from experience, and giving students responsibility for their own learning. These beliefs together influence his planning. He designs a variety of activities, collects much interesting information, and puts stories into his lessons so students can experience these activities by themselves and can maintain their interest in learning.

Conceptual learning is also important for Chuck so he plans a lot of examples to explain science concepts to his students. He also believes that because science is tentative truth, students need to be independent thinkers and develop analytic ability. These beliefs influence his lesson goals and influence the way he designs more essay questions into his assignments.

Sally believes in the importance of teaching content and in showing the applications of that content to students. During her planning, she organizes content to present it to students as relevant to their daily lives. Sally also believes in making

things interesting, keeping students involved, and stimulating students to learn. These beliefs cause her to plan a variety of hands-on activities and lab discussions into her lessons.

All the student teachers seem to have similar goals: to maintain their students' interest in learning and to engage them in learning activities. These goals constantly dominate their planning. They strive for a variety of teaching methods and activities and to present interesting information.

The prospective teachers express similar beliefs in maintaining students' interest in learning and in engaging them in learning activities. But, the reasoning behind their planning actions is quite different. Tina not only focuses on activities, but also prefers using work-sheets to enhance student learning. So she puts great effort into designing work-sheets during her planning. Chuck uses activities not only to maintain student interest, but also to give students responsibility for their learning. Sally believes more in the practical application of knowledge so her lesson plans provide a lot of practical content knowledge to students.

Relationship between Teaching and Beliefs

As mentioned before, Tina does not prefer discussion unless it can express the constantly changing nature of science. Sometimes she uses discussion in her classroom because she thinks that discussion not only helps students to see how science relates to their daily lives, but also allows students to appreciate the dynamic nature of science. Tina also believes that experiencing lab processes is more important than getting

correct lab results. During lab activities, she often reminds her students of this.

Tina also expects students to be actively involved and responsible for their learning. During labs, she expects students to find the answers to questions relating to lab procedures by themselves instead of waiting for her to provide the answers.

Tina's classroom teaching style follows the pattern of lectures, discussion, and doing work-sheets. This procedure is influenced by her beliefs that new information should be presented in a lecture format and that discussions and work-sheets can reinforce student learning.

Chuck believes strongly that students learn by themselves and that they should be responsible for their learning. These beliefs lead Chuck to conduct a lot of classroom activities so that students can learn by themselves. Chuck also believes that teachers should maintain student interest so he changes his teaching style often in order to keep students involved.

Sally believes in using a variety of teaching methods to maintain student interest in learning. She uses a lot of lab activities, visual displays, and small discussions in class. Sally also believes that creating a comfortable learning environment is important. She has such a pleasant and informal personality, and the whole classroom atmosphere is so pleasant that students feel free to express themselves in class.

Sally also believes that science teachers should begin with simple, basic information and then, help students to see the

applications of this information to their daily lives. Sally always teaches lessons in a simple way and explains things to students in an easy, understandable manner.

Two of the student teachers believe that maintaining student interest is very important in their teaching. They try to use various activities or interesting information to maintain student interest in learning.

While these teachers use similar teaching strategies in their classrooms, the beliefs dominating their teaching differ. For instance, Chuck believes that making students take responsibility is most important. He also uses a variety of activities to allow students to learn by themselves. Tina uses discussion to help students understand the nature of science and to develop their appreciation of their environment.

Chuck and Tina both believe that students need to take responsibility for their own learning. Chuck expects students to act responsibly in learning by themselves during group activity, while Tina asks students to responsible in finding answers for their own questions by themselves.

Conclusions and Implications

This study finds that the three secondary science teachers have articulated similar beliefs about science, and pedagogy. However, the context and meaning behind their words has subtle differences, which also influenced their performance during planning and teaching. On the other hand, their performance are sometimes similar, while the beliefs on which they acted differ.

The shared beliefs among these prospective secondary science teachers were that science constantly changes and that students need to be taught science process skills. They also believed that learning should involve concrete experiences and that students should be held responsible for learning. They should provide comfortable learning environments, transfer science content knowledge, and model learning for students. Teachers should also maintain and spark students' interest in learning and help students to build up their confidence. These prospective teachers' beliefs about their students sometimes conflict with reality, causing them problems during teaching.

My findings also indicate that student teachers' beliefs influence their planning and teaching behaviors, supporting the previous consensus (Thompson, 1982; Hollon & Anderson, 1987). However, the complex nature of belief systems makes the relationship between beliefs and actions difficult to predict. This study has found that although preservice secondary science teachers hold a variety of beliefs about science and pedagogy, not all the beliefs they articulate influence their planning and teaching. Which beliefs dominate teachers' actions depend on the situation as demonstrated by Elbaz (1981).

Although these student teacher inform the importance in science and science teaching, but in their real classroom teaching, most of students address the importance in maintaining students' interests in learning. They use hands-on activity as means to reach their interests-capturing goals. Albeit these

informants described their beliefs seems very pleasant to most of science educators. It is possible they just learned from their teacher education program. The question then comes whether these preservice science teachers would constantly implement what they believe about science and science teaching in their future classroom? Besides the influence from teacher education program, what are other factors influence the evolving of these preservice secondary science teachers' beliefs about science and science teaching in the future? Looking at these prospective teachers' teaching patterns (See Appendix I to III), it seems that some patterns, such as reviewing of lessons or tests, etc. do not relate to their explicit beliefs. Then what are the beliefs besides the ones they articulated dominate their actual classroom teaching? These are the uncover questions raided by this study, and need to be investigated by future research.

The study suggests that because so many preservice teachers articulate similar beliefs but their underline context are quiet different. Therefore, the best way for science educators introduce learning theories to their students is for them to speak out what they mean by providing substantial reasoning on their responses. Self-reflection on one's action could help these preservice teachers to be aware of their own thinking and performance.

Tina

Tina's beliefs about science and pedagogy (Numbers represent beliefs referred below)

1. Science is constantly changing and is problem solving about the environmental issues.	8. Discussión is a good teaching method.
2. Learning should be interesting.	9. Work-sheets are good for learning.
3. Experiencing science activities is more important than getting correct results.	10. Teaching should be interesting.
4. Hands-on activities can maintain Ss' interest.	11. Lower scientific language to Ss' level.
5. Ss take responsibility for learning.	12. Teaching styles and goals depend on topics.
6. T should teach content information to Ss.	13. T should be knowledgeable.
7. Lectures and demonstrations are good teaching methods.	14. T should be role model.
	15. T should maintain Ss' interest in learning.

How Tina's beliefs influenced her planning and teaching (Numbers represent her beliefs mentioned above)

Belief (No.)	it had the following influences on her planning, she:	Belief (No.)	it had the following influences on her teaching, she:
15	• prepared many teaching activities.	1	• conducted group discussion in some of topics.
9	• designed work-sheets in math & chemistry classes.	3	• expressed expectations constantly to Ss during lab activities.
		5	• expected Ss to answer lab procedures Qs by themselves.
		7, 8, & 9	• varies her teaching styles with lectures, demonstrations, discussions, & work-sheets.

Tina's teaching pattern during nine classroom observations

Lesson 1	Direction (5 min); Lab activities (40 min)	Lesson 6	Show film (15 min); Work on math problem (10 min); Show film (20 min)
Lesson 2	Direction (5 min); Lab activities (40 min)		
Lesson 3	Introduce theorem with demonstration problem solving (9 min); Work-sheets (27 min); Summary (8 min)	Lesson 7	Lecture with demonstration problem solving (7 min); Work-sheets (35 min)
Lesson 4	Lecture (7 min); Whole class activities (24 min); Lecture (24 min)	Lesson 8	Lecture (16 min); Whole class activities (16 min); Lecture (10 min)
Lesson 5	Lab activities (50 min).	Lesson 9	Demonstration problem solving (10 min); Work on problems with Ss (20 min); Ss work on problem solving exercises (20 min)

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Appendix II

Chuck

• Chuck's beliefs about science and pedagogy (Numbers represent beliefs referred below)

1. Science is constantly changing. 2. Ss should use scientific methods to study nature. 3. Learning should come from Ss' intrinsic motivation. 4. Learning should be enjoyable. 5. Ss should be free to express themselves. 6. Learning should be by experience. 7. Conceptual learning is important.	8. Ss should take responsibility for their learning. 9. T should engage Ss in learning. 10. T should help Ss to become independent thinkers and problem solvers. 11. T should act as good role model. 12. T should provide a comfortable & activity-oriented learning environment. 13. T should maintain Ss' interest in learning.

• How Chuck's beliefs influenced his planning and teaching (Numbers represent his beliefs mentioned above)

Belief (No.)	it had the following influences on his planning, he:	Belief (No.)	it had the following influences on his teaching, he:
6, 8, & 13 7 10	• designed many activities used in the lessons. • collected interesting information and stories in the lessons. • designed many examples to explain science concepts. • designed essay Qs for the assignments.	6 & 8 13	• conducted a lot of classroom activities in his teaching. • changed his teaching styles constantly to attract Ss' interest in learning.

• Chuck's teaching pattern during nine classroom observations

Lesson 1	Reviewed lessons by constantly posing Qs & explaining concepts (50 min).	Lesson 6	Group activities (35 min); Lecture (15 min).
		Lesson 7	Ss presented their projects (19 min); Reviewed lesson (30 min).
Lesson 2	Group activities (50 min).	Lesson 8	Lecture (22 min); Discussed test Qs (11 min); Lab activities (12 min).
Lesson 3	Discussed test Qs with Ss by constantly posing Qs (50 min).		
Lesson 4	Reviewed previous lesson (12 min); Introduce concept map (25 min); Group activities (12 min).	Lesson 9	Introduced concept map (10 min); Group activities (25 min); Summary of the lesson (10 min).
Lesson 5	Lectured by constantly posing Qs (50 min).		

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Appendix III

Sally

* Sally's beliefs about science and pedagogy (Numbers represent beliefs referred below)

1. Science is the appreciation of the living environment around people.	7. Teaching should interact with Ss.
2. Ss should have intrinsic motivation in learning.	8. Teaching should maintain dynamic learning environment.
3. Ss should take responsibility for their learning.	9. T should build up Ss' confidence.
4. Ss should be curious about their living environment.	10. T should provide comfortable, pleasant learning environment.
5. T needs to organize content knowledge.	11. T should involve Ss in learning.
6. T should show Ss the application of content knowledge.	12. T should maintain or spark Ss' interests in learning.

* How Sally's beliefs influenced her planning and teaching (Numbers represent beliefs mentioned above)

Belief (No.)	it had the following influences on her planning, she:	Belief (No.)	it had the following influences on her teaching, she:
5	* organized content knowledge and prepared examples to show Ss.	8 & 12	* used a lot of lab activities, visual display & small discussion.
11 & 12	* designed variety of hands-on activities and lab discussions.	10	* had a pleasant and informal personality which created a pleasant learning environment.
		5 & 6	* presented content information in simple and basic format, she also showed application of content to Ss.

* Sally's teaching pattern during nine classroom observations

Lesson 1	Direction (5 min); Group activities (27 min); Individual work (10 min)	Lesson 6	Ss read textbook, and T asked Qs from textbook (50 min).
Lesson 2	Direction (9 min); Group activities (35 min)	Lesson 7	Discussion (9 min); Individual work on work-sheets (30 min); Passed samples onto Ss (5 min).
Lesson 3	Review test (15 min); Lecture (29 min)	Lesson 8	Lecture (16 min); Demonstration (4 min); Discussion homework (15 min).
Lesson 4	Ss read textbook, T constantly posing Qs to Ss (50 min)		
Lesson 5	Discussion (20 min); Direction (5 min); Activities (15 min)		

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